Update of the ASTRONET Science Vision & Infrastructure Roadmaps

Ian Robson
Mid-term, light-touch update

- Responsibility of STFC
- Science Vision updated mainly by the Chairs/co Chairs of the original Science Vision Working Groups along with Members at Large
- The SV update was complete as of Feb 2013
- Final draft agreed by the ASTRONET Board and Executive in May 2013
- Now available at: http://www.astronet-eu.org
The ASTRONET Science Vision for European Astronomy was published in 2007. Click here for the update 2012: http://www.astronet-eu.org/spip.php...
Contributors

Panel A: John Peacock, Claes Fransson
Panel B: Jacqueline Bergeron, Rob Kennicutt
Panel C: Leonardo Testi
Panel D: Therese Encrenaz, Richard Harrison, Valentin Martinez Pillet, Ian Wright, Charles Cockell

Members at Large and others:
Catherine Turon, Alvio Renzini, Bruno Leibundgut
Science Vision Update

Recommendations

- For the *current facilities* sections, the revised status of the missions/facilities/instruments is updated – there is very little change from the original recommendations.

- For the *future facilities*, where there are changes and new recommendations, these are given in the following slides.
'Do we understand the extremes of the Universe?'

- An X-ray survey satellite will be essential for goals 1, 2 & 6. Large-area X-ray imaging is important both for the detection of clusters of galaxies, and also for monitoring to detect transient explosive sources;
- While no current facility to achieve these goals is approved, eRosita will provide an imaging and spectral all-sky survey and the LOFT mission (ESA candidate M3 proposal) will provide some transient detection capability
- Plans need to be put in place for a follow-on mission to SWIFT to monitor and localise gamma-ray bursts.
‘How do galaxies form and evolve?’ – current facilities

- VISTA essential for goal 2 by providing detections of candidates for the highest redshift quasars and galaxies before JWST, and complementary for goals 3 and 6 from its wide-field deep infrared imaging surveys.

- VLT essential for goal 7 by providing complementary spectroscopy for samples of order $10^5$ stars in the Galaxy to measure chemical abundances and kinematics and the Gaia-ESO public survey is under way.

- eRosita will be essential for goal 3 and complementary for goals 1 and 6 by providing the first imaging all-sky survey in hard X-rays, and identify tens of thousands of distant galaxy clusters and millions of accreting black holes.

- Euclid will be essential for goal 1 in providing definitive constraints on the dark energy equation of state, and complementary for goal 6, by providing enormous inventories of precise imaging, spectra, and redshifts for distant galaxies and complementary for goal 6 & 7 for stars in our Galaxy.
‘How do galaxies form and evolve?’ – future facilities

- An X-ray space mission with moderate-resolution spectroscopy (R~1000) will be essential for goals 2 & 5, and complementary for goals 3 & 4. This mission should address key problems relating to the intergalactic medium, missing baryons, black hole evolution, and galaxy assembly;
- There needs to be an X-ray mission to achieve these goals, currently none approved.

- A 4–8 m ultraviolet space telescope will be essential for goal 4, and complementary for goals 2, 5 & 6. Such a facility could obtain high-resolution imaging and spectroscopy of galaxies and background quasars over thousands of sightlines in the Universe, and trace the evolution of intergalactic baryons and the exchange of matter and metals between galaxies and the intergalactic medium over cosmic time;
- This remains an important requirement and it should be addressed in the next Science Vision ‘decadal’
‘How do galaxies form and evolve?’ – future facilities

- A 4–8 m cooled infrared telescope for spectroscopy will be essential for goal 6. It will trace dust-obscured galaxy formation, star formation, and black hole formation and growth back to the reionization epoch;

- This remains an important goal and is in principle satisfied by SPICA, which awaits further mission clarification by JAXA

- A far-infrared space interferometer will be complementary for goals 3 & 6 in connection with ALMA. It would allow observations of H2 molecules at high redshift (dust-obscured and shock-heated regions).

- This remains an important requirement and it should be addressed in the next Science Vision ‘decadal’
What is the origin and evolution of stars and planets? – future facilities

- The next generation of high precision radial velocity monitoring instruments will be essential for goals 5 & 6, and complementary for goal 3; with a velocity resolution better than 0.1 m/sec it allows the detection of earth like planets in habitable zones around solar type stars.

- This remains an important goal and following from the major successes in this area, now is an appropriate time to reformulate this goals with specific requirements.

- High accuracy and stability infrared spectroscopy from space is an essential step to achieve the accuracy and sensitivity needed for the spectroscopic characterization of exoplanets and achieve goals 5 and 6 – the EChO candidate ESA M3 mission would be the first steps along the road.
How do we fit in? – future facilities

- A medium-aperture (1–2m) (extreme-) ultraviolet satellite facility with X-ray capabilities, incorporating sub-arcsecond resolution imaging and spectroscopy, cadences down to seconds and wavelength selections appropriate to the temperature range of the Solar atmosphere – up to relativistic electrons – including, for the first time, (extreme-)ultraviolet magnetic mapping of the Solar transition region and corona, to study fundamental Solar processes that cannot be studied from the ground, is essential for goal 1(i) and complementary for goals 2 and 3;

- The Japanese Solar-C (1.5m) mission meets most of these requirements and ESA sees this as a ‘Target of opportunity’. The European involvement would focus on UV spectroscopy and the mission also includes X-ray imaging
How do we fit in? – future facilities

- An in situ mission probing simultaneously the three major scales of the physical processes in the magnetosphere and Solar wind involving a fleet of spacecraft forming three embedded tetrahedrons. Essential for goals 1(ii), 1(iii) and 2;
- The science remains important but there is no European mission to achieve this; in the USA, MMS is under development by NASA for a launch in 2014.
- A high quality network of ground-based radars, such as SuperDARN and the next-generation EISCAT facility, providing both global context for the magnetospheric missions and specific detailed measurements in support of conjugate studies. Essential for goal 1(iii) and 2;
- Planned upgrade to EISCAT-3D is on the ESFRIT Roadmap;
- Participation in an international network of ground-based, synoptic instruments that monitor continuously the full-disc solar spectral irradiance and magnetic and velocity fields is complementary for goals 1(i), 2 & 3;
- The ground-based network that fulfils this goal is the National Solar Observatory SOLIS network (USA)
What’s changed since 2008?

- ESA selection of M1/M2, L1, S1 and the process for L2/L3
- ASPERA Roadmap
  

- Economic situation in Europe and ‘flat-cash’ budgets at best
- Increased funding competition between existing and new facilities/missions
What's changed - a reminder – current ESA Cosmic Visions status

**M-class missions (M1 & M2)**

**Solar Orbiter (2017)**  a mission to produce images of the Sun at an unprecedented resolution and perform the closest-ever measurements of local near-Sun phenomena

**Euclid (2020)**  to map the geometry of the dark Universe, measuring the distance-redshift relation and the growth of structure by using two complementary DE probing methods: baryon acoustic oscillations and weak gravitational lensing

**SPICA (????)**  The European contribution to SPICA is currently in an extended assessment phase, keeping it in line with the status of the project at JAXA.

**L1 Mission (2022)**

**JUICE**  a mission to study the giant gaseous planet Jupiter and its moons Io, Europa, Ganymede and Callisto in unprecedented detail.

**S1 Mission (2017)**

**CHEOPS**  a mission to characterize transiting exoplanets on known bright and nearby host stars

**M3 Candidates - 2024 launch, selection beginning of 2014**

**EChO**  to investigate exoplanetary atmospheres, addressing the suitability of those planets for life and placing our Solar System in context

**LOFT**  to address fundamental questions about the motion of matter orbiting close to the event horizon of black holes and the state of matter in neutron stars, by detecting their very rapid changes in X-ray flux and spectral variability.

**MarcoPolo-R**  to return a sample of material from a primitive near-Earth asteroid for detailed analysis in ground-based laboratories. The scientific data would help to answer key questions about the processes that occurred during planet formation and the evolution of the rocks that were the building blocks of terrestrial planets.

**PLATO**  to open a new way in exoplanetary science, by providing a full statistical analysis of exoplanetary systems around stars that are bright and nearby enough to allow for simultaneous and/or later detailed studies of their host stars

**STE-QUEST**  to precisely measure the effects of gravity on time and matter. Its main objective would be to test the Principle of Equivalence, a fundamental assumption of Einstein's Theory of General Relativity
First call 2009 for R&D for CTA and Dark Matter with further Calls in 2010 and 2012

Looking to go ahead as top priorities with:
- CTA construction beginning 2014
- KM3NET (in ESFRI), AugerNEXT, LAGUNA start of construction should be between 2014 and 2016 – but recognised as probably too ambitious for funding of everything!
- Support for EUCLID, theoretical studies etc
Infrastructure Roadmap Update

Original Infrastructure Working Groups recommendations etc, as taken from the Roadmap Document

Panel A: High Energy Astrophysics, Astroparticle Astrophysics and Gravitational Waves

The updates are given in yellow text
High Priority New Projects

- **Near-term (~2015):**
  - CTA in three-year prep phase to 2013
  - KM3NeT first module deployed April 2013, awaiting full funding
  - Simbol-X (Fr-It X-ray telescope 0.5-100 keV) Cancelled
  - eROSITA medium energy X-ray all-sky imaging and spectroscopic survey instrument to be launched in 2014 on the Spectrum-Rontgen-Gamma satellite (mainly Germany-Russia)

- **Medium-term (~2016-2020):**
  - XEUS/IXO/=ATHENA not selected for L1, white paper L2/L3
  - LISA not selected for L1, eLISA white paper submission for ESA L2/L3
  - LOFT – candidate mission for M3
Current missions

- XMM-Newton, INTEGRAL ✔ ESA extension to end of 2016
  with a mid-term review in late 2014

- Gaps and Tech Dev:
  Imaging & spectroscopy in 0.1-10MeV; all-sky X-γ monitoring for transients; GRB follow-up – status of SVOM ??
Panel B: Ultraviolet, Optical, Infrared and Radio/mm Astronomy
High Priority New Projects

Near-term (~2015):
- Development of wide-field, multiplexed spectrometers for large optical telescopes ✓ MOONS selected by ESO along with further work on 4MOST; WEAVE underway – good success overall
- Gaia data analysis and processing ✓ well in-hand

Medium-term (~2016-2020)
- E-ELT ✓ approved by ESO, almost fully funded, project well advanced with infrastructure and long lead-time construction underway
- SKA ✓ project office now in-place, Director in-post; sites selected and first tranche funding in-place, multi-national consortium
- EUCLID ✓ now approved as M2 by ESA for launch in 2020
- SPICA status (funding) within ESA remains as – “Mission of Opportunity” and awaits JAXA decision
- CHEOPS ✓ selected for ESA S1 for launch in 2017
High Priority New Projects

- **Long Term (~2020+)**
  - **PLATO** re-submitted from M1/M2 as ESA M3 candidate mission
  - **EChO** candidate new mission for ESA M3
  - **DARWIN** not selected for L1 competition; new exoplanet white paper theme of *Exploring Habitable Worlds beyond our Solar System* submitted for ESA L2/L3
  - **FIRI** not selected for L1 competition; white paper theme of *Advanced High Angular Resolution in the Far Infrared* submitted for ESA L2/L3
  - *Polarized radiation Imaging and Spectroscopic Mission* white paper theme submitted for ESA L2/L3
Current missions

- JWST now scheduled for launch in 2018
Existing facilities

- Optical and Infrared 2-4m telescopes ✓
  - Report by ASTRONET ETSRC May 2010– Janet Drew & Task 5.1
    ‘Implementation of the ETSRC recommendations for the cost-benefit optimisation of the operation of the European optical/IR 2-4m telescopes’ (Jesus Gallego – see later talk). Transnational access - OPTICON

- 8-10m class optical telescopes ✓ASTRONET work about to start, ESO undertaking review of role of the VLT in the realm of the E-ELT

- Radio Observatories ✓
  - ALMA now almost complete, SKA Pathfinders now operating
  - Transnational access through RadioNet
  - Ongoing ASTRONET Radio working group (ERTSRC) – Ralph Wijers, work in progress – see later talk

- Near millimetre and submillimetre facilities this is getting urgent and is not covered in the review above – action needed by ASTRONET

- Gaps and Tech Dev: lots of work here! Significant work to be done on this topic
Panel C: Solar Telescopes, Solar System Missions, Laboratory Studies
High Priority New Projects

- **Near-term (~2015):**
  - Solar Orbiter ✓ selected for M1 launch in 2017, very high priority.

- **Medium-term (~2016-2020):**
  - EST highest priority for European solar physics; co design study completed in 2011, design/construction funding not yet secured. EU FP7 SOLORNET provides funding of €6M for 2013-17 to support access to existing facilities on the Canary Islands, tech development, data handling – all for EST prep. Seeking to include EST in the next ESFRI Roadmap.

  - Cross-Scale not selected for M1/M2, space plasma mission, science remains important but no European mission to achieve it. MMS is under development by NASA for 2014 launch.
High Priority New Projects update

- **Medium-term (~2016-2020)**
  - Marco Polo: not selected for ESA M1/M2 but returning samples remains of highest importance and is the highest priority in this category. This mission is currently competing for selection as ESA M3.
  - TandEM: not selected for L1 but remains of high importance and may be resurrected again in the long-term flagship missions.
  - Laplace: selected for L1 as JUICE for launch in 2022 and approach Jovian system in 2030 with subsequent flybys of Ganymede and Callisto, and orbit Ganymede in 2032.

- **Long-term (2020+)**
  - PHOIBOS: not selected for further study but many of the scientific objectives are covered by NASA’s SolarProbe mission.
Current missions

- Cluster, Hinode, MarsExpress, SOHO, VenusExpress all doing very well and have been extended until the end of 2016 with mid-term reviews in 2014.
- The launch of BepiColombo has slipped to beyond summer 2015.
- ExoMars: top priority for European planetary community and this is an essential component. However, this mission has been reshaped several times since 2007 – NASA now withdrawn, project is now ESA+Russia and includes orbiter and lander with first launch planned for 2016. A rover for exobiology studies (drilling) will be launched 2 years later. In parallel the NASA mission InSight to be launched 2016 (seismology).
Gaps and Tech Dev:

- radio spectral imaging of the Sun at cm-m wavelengths. This remains a gap although solar imaging with LOFAR and ALMA will fulfill some of the science goals.

- medium-aperture (1-2m) extreme UV satellite with X-ray capabilities. The Japanese Solar-C satellite fulfils most of the science requirements. Europe, the US, and Japan have proposed that ESA leads the development of a large EUV/FUV high-throughput telescope feeding a scientific payload of high-resolution imaging spectrographs and cameras. This scientific payload is to be provided by an international consortium with European, US and Japanese partners funded by their respective national agencies and institutes - LEMUR.

A relevant European participation is also envisaged in the 1.5m UV-visual-IR telescope, in particular to the primary and secondary mirrors of the 1.5m telescope (ideally to be provided by ESA) and to the spectropolarimeter.

Also see task 4.5: Implementation of Roadmap recommendations to organise and strengthen Laboratory Astrophysics research in Europe (Ronald Stark – see later).
Panel D: Theory, Computing Facilities and Networks, Virtual Observatory
Also see ASTRONET task 4.4: VO and Astrophysical Software Lab (Jean-Marie Hameury)

- Acceptance of future massive (spectroscopic) data sets and open access
- Good progress on the VO, especially in Europe (coordination, assistance); international standards now in place through the IVOA; interoperability of tools for diverse catalogues and multi-catalogue searching
- Proposal for funding of the Astrophysical Software Laboratory is being addressed by ASTRONET
- Note of caution about super-computing infrastructure requirements and massive simulations of the future
- Need to develop new algorithmic techniques for future Exascale supercomputing development
Panel E: Education, Recruitment and Training, Public Outreach

- Yet to be started – work over summer 2013
- Good news story with IYA2009 and the rise of astronomy and science outreach since, along with citizen science data mining -’Zooniverse’
- Governments – the Economic Impact agenda
- See later talk by J-G Cuby
The funding situation

- Not brilliant! (but not desperate either)

- Meeting of national funding agencies in the early autumn to discuss the funding (ex ESA/ESO/etc) potentially available – both for projects, technology development and staff (students, postdocs, project staff)
What now needs to be done?

- What have we missed?
- Where are the gaps – especially in the area of new technologies?
- Where are the overlaps with others?

- Community input requested
- Timescale – over the summer into autumn
- Need to publicise to the astro communities in the EU countries – ASTRONET Board
Who to contact

- Panel A: Patrizia Caraveo, Ralph Wijers
- Panel B: Michael Grewing, Laurent Vigroux
- Panel C: Mats Carlsson, Therese Encrenaz
- Panel D: Mark Allen, Mattias Steinmetz
- Members at Large: Xavier Barcons, Gerry Gilmore, Thijs van der Hulst, Hans Walter Rix
- myself
email addresses

pat@iasf-milano.inaf.it       R.A.M.J.Wijers@uva.nl

grewing@iram.fr              vigroux@iap.fr

Mats.carlsson@astro.uio.no   Therese.Encrenaz@obspm.fr

mark.allen@astro.unistra.fr msteinmetz@aip.de

barcons@ifca.unican.es; gil@ast.cam.ac.uk; vdhulst@astro.rug.nl; rix@mpi.de;

ian.robson@stfc.ac.uk